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## Abstract

Although much research has been done on the relationship between vision and learning, there is still much debate regarding which tests should be done during a vision screening to accurately identify those children whose academic performance is being affected by their visual skills. In an attempt determine which tests would best predict academic performance, we analyzed records from a vision screening on a group of school aged children from San Blas, Mexico. 447 children, ages 5 to 13, were given a free vision screening. Their teachers were asked to rate each child's performance in reading and math on scale of 1 to 5. Those findings were then compared to the child's near visual acuity, near cover test, near point of convergence, stereo acuity, and refractive error. No clinically significant correlation was found between those visual skills measured and academic performance as rated by each child's teacher. This could be partly due to the limited tests performed. Future screenings that include tests of visual skills, such as saccadic eye movements and visual motor integration, which directly affect a child's ability to read and learn, would probably be better predictors of academic performance than those tests performed at our screening.



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vision screening, learning, children, academic performance, reading ability

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# A Retrospective Analysis of the Relationship between Reading and Math Abilities and Visual Function in a Hispanic Elementary Age Population

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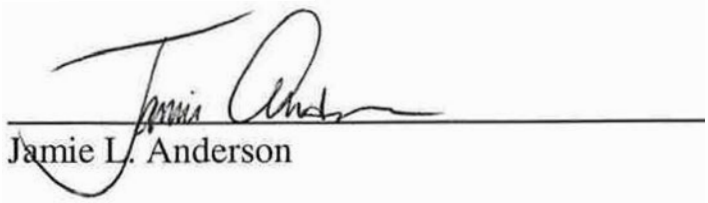

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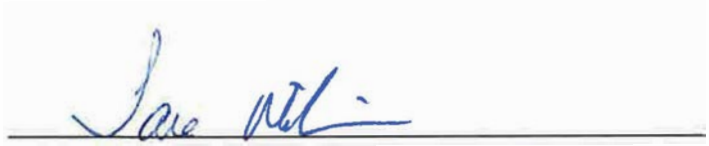

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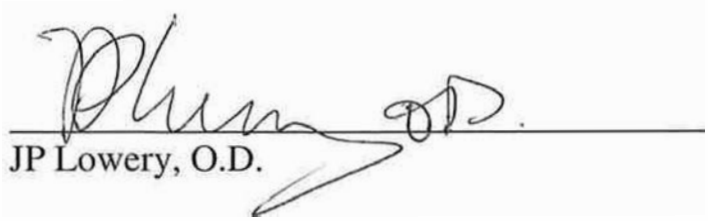

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Biographies:

Jamie Anderson attended the University of Colorado at Boulder and graduated with a Bachelor's degree in Business/Finance in 1997. She grew up in Colorado and hopes to return there to practice optometry after graduating from Pacific University College of Optometry. Her optometric interests include pediatric optometry, contact lenses, and neuro-rehabilitative optometry.

Sara Williams attended Pacific University in Forest Grove and graduated in 2000 with a Bachelor's degree in Biology. After attaining her Doctorate in Optometry from Pacific University, she hopes to practice optometry in a private setting. Ideally, her future practice will specialize in contact lenses, pediatrics, neuro-rehabilitative optometry, and vision therapy.

Abstract

Although much research has been done on the relationship between vision and learning, there is still much debate regarding which tests should be done during a vision screening to accurately identify those children whose academic performance is being affected by their visual skills. In an attempt determine which tests would best predict academic performance, we analyzed records from a vision screening on a group of school aged children from San Blas, Mexico. 447 children, ages 5 to 13, were given a free vision screening. Their teachers were asked to rate each child's performance in reading and math on scale of 1 to 5. Those findings were then compared to the child's near visual acuity, near cover test, near point of convergence, stereo acuity, and refractive error. No clinically significant correlation was found between those visual skills measured and academic performance as rated by each child's teacher. This could be partly due to the limited tests performed. Future screenings that include tests of visual skills, such as saccadic eye movements and visual motor integration, which directly affect a child's ability to read and learn, would probably be better predictors of academic performance than those tests performed at our screening.
Key words: Vision screening, learning, children, academic performance, reading ability.

# A Retrospective Analysis of the Relationship between Reading and Math Abilities and Visual Function in a Hispanic Elementary Age Population

**Anderson, JL and Williams, SR**

## Introduction

Vision plays an important role in a child's ability to perform well in school. It is the most important link between the child's physical world and their mental world. There are numerous parameters and subsystems that that determine the overall efficiency of the visual system. These include refractive status, stereo acuity, oculomotor slulls, and fusional vergence slulls. There is conflicting research as to how deficient visual skills may contribute to learning disabilities, particularly reading disorders. Many studies show little correlation between visual acuity and reading ability, although a few studies have shown that poor near acuity is more common among poor readers.[1] However, there have been studies that have documented a significant correlation between refractive-status, particularly hyperopia, with decreased academic performance[1,2], and with delays in perceptual development.[3,4]

Binocular vision problems, including high exophoria at near, low fusional vergence reserves, anisometropia and aniseikonia, convergence insufficiency, and fixation disparity have all been shown to be significantly higher in the learning disabled population.[5] Research has also shown that eye movements, specifically saccades, are essential to the learning process. For example, in a screening on a pediatric population, Krumholtz found that saccadic eye movements are correlated with academic performance.[2] However, other

research has shown that the reading disabled population can have normal saccadic ability, and still have difficulty reading as a result of poor processing ability.[7]

Although there has been much research done regarding the relationship between visual skills and learning ability, there is still much debate among professionals as to the depth of that relationship. Most studies focus on how visual skills affect learning to read, but there are others that acknowledge the difference between learning to read and reading to learn. For example, Kiely et al. found that there was no correlation between visual parameters and reading performance in a population of learning disabled children. Yet he suggests that 39% of these children are expected to have difficulty reading to learn as a result of their visual skills.[7] There are many variables, other than vision, that can affect and contaminate the results of these studies, such as a child's intelligence and language processing ability. In a study comparing visual problems with phonological problems, Eden et al. suggests that faulty language processing is a primary cause of reading problems among the learning disabled population. However, he also found that combining visual and verbal skills could significantly predict reading ability.[8] There has also been a lack of standardization as to when a visual skill is considered deficient. Each study has set its own pass/fail criteria. Rather than using a standardized testing battery, these studies have used a different series of tests to evaluate the same visual skills, thereby making the comparison between studies difficult. As a result of all these variables, research has established a complex link between vision and learning ability.

In an attempt to clarify the relationship between a child's academic performance and his visual system, we analyzed records from a vision screening on a group of school aged

children. Results of the vision screening are compared to a scaled score of academic performance in both math and reading.

**Methods**

After collecting this data we analyzed the results to assess whether there was a relationship between the children's school performance and the screening results. This screening was conducted by AMIGO's, a student run, non-profit organization from Pacific University College of Optometry, along with the Lion's Club. Optometry students collected most of the data, although two Optometrists did all of the retinoscopy to determine refractive error and Lion's Club members and interpreters helped take case history and visual acuities.

447 children, ages 5 to 13, were given a free vision screening. Their teachers also accompanied them to the screening. Teachers were asked to rate each child's performance in reading and math, separately, on a scale of 1 to 5, with 1 being poor and 5 being excellent. The scale used was as follows:

| |
|---|
| 1 = Far below grade level |
| 2 = Slightly below grade level |
| 3 = At grade level |
| 4 = Slightly above grade level |
| 5 = Far above grade level |

Then the child's visual acuities were taken at both 20 feet and 40 cm. A cover test was performed at distance and 40 cm to determine the child's phoric posture at near. Near point of convergence was also performed, using a bead, and their break was recorded. Stereo acuity was measured using the LANG I stereoacuity test. Refractive error was measured via dry retinoscopy. The only data for which we know there was consistency in how it was measured was refractive error. The data was obtained via retinoscopy, which was performed

by two experienced optometrists. Children with significant hyperopia or other clinical indicators were cyclopleged with 1% Tropicamide and retinoscopy was repeated to obtain a more accurate refractive measure. Our analysis was based upon the findings of the dry retinoscopy results.

**Results**

Of 447 children screened, we looked at those children who were rated by their teachers as performing at a level of 1 or 2, based on a scale of 1 to 5 (with 1 being the poorest reader), and compared that group to those who performed at an academic level of 4 or 5. We then compared the means of each group's near visual acuity, near cover test, near point of convergence, stereo acuity, and refractive error (Table 1). We did not analyze distance visual acuities or the distance cover test results because they would be expected to have minimal effect on near academic performance.

TABLE 1

**MEAN VALUES:**

| | Reading 1,2 | | Reading 3 | | Reading 4,5 | | | Math *1,2* | | Math 3 | | Math 4,5 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Near VA:** | OU | | OU | | OU | | | OU | | OU | | OU | |
| (logMAR) | -0.19 | | -0.19 | | -0.17 | | | -0.19 | | -0.18 | | -0.18 | |
| | | | | | | | | | | | | | |
| **Refractive Error:** | OD | OS | OD | OS | OD | OS | | OD | OS | OD | OS | OD | OS |
| (diopters) | 0.77 | 0.87 | 0.49 | 0.59 | 0.58 | 0.63 | | 0.66 | 0.69 | 0.63 | 0.74 | 0.57 | 0.64 |
| | | | | | | | | | | | | | |
| **Cylinder:** | OD | OS | OD | OS | OD | OS | | OD | OS | OD | OS | OD | OS |
| (diopters) | -1.12 | -1.02 | -1.11 | -1.13 | -0.75 | -0.93 | | -1.22 | -1.39 | -0.87 | -0.95 | -0.83 | -0.88 |

In comparing near visual acuities, near cover test, stereo acuity, and near point of convergence, we did not find any clinically significant difference between the poorer

academic performers who scored a 1 or 2 on math or reading ability, and those who scored a 4 or 5. For example, the average visual acuity for all groups ranged from -0.17 to -0.19 (log mar), which is approximately 20130 Snellen acuity. The two areas that showed the biggest difference were overall refractive error and the amount of astigmatism present in that refractive error. For example, the mean cylinder value found on the left eye of those who scored a 1 or 2 in math was -1.39 while those who scored a 4 or 5 in math had a mean value of -0.88. This is just over a 0.50 diopter difference between the two groups. Overall refractive error was analyzed by looking at the spherical equivalent for each eye. Those who scored a 1 or 2 were found to be slightly more hyperopic. For example, the mean refractive error in the left eye of those who scored a 1 or 2 in reading was 0.87 while those who scored a 4 or 5 had a mean refractive error of 0.63. This is a difference of almost a 0.25 diopter difference in hyperopia. However this difference, clinically, would not be considered significant.

**Discussion**

Our results indicate that there is no clinically significant correlation between academic performance and the visual skills measured in our study population. However, our sample size only had a small number of children with significantly deviant visual skills. Some research indicates that children who have high hyperopia will perform more poorly academically. However, of the 447 participants screened only seven children had refractive error greater than or equal to +3.00 diopters and only sixteen had a refractive error of +2.00 or greater. The majority of our sample had a normal, slightly hyperopic refractive error. If we had a larger sample with hyperopia of greater than 2.00 diopters, it is possible we would

see a link between decreased academic performance and refractive error. This is also applicable for all other visual skills tested, as most of the children screened had normal results.

Research does show that there are other visual factors that more significantly correlate with academic performance. These include saccadic eye movements, accommodative function, and visual motor skills. Specifically, the VMI and the Wold Sentence Copy tests in one study were shown to be the best predictors of academic success.[9] We would have liked to have performed these tests as well. However, they were outside the scope of this humanitarian screening.

We also need to draw attention to some weaknesses inherent in this clinically-based study. The scoring method for evaluating the children's academic performance in math and reading may have been invalid. We are unsure sure whether both the teachers and our interpreters understood the scale, or if they read it correctly when evaluating the children. Some may have interpreted 1 as being the best performer and 5 as being the worst. There were also many different students performing the tests so there may have been some variation in techniques used which in turn could have led to inconsistency in the data collected. Because this was just a screening, with many kids needing to be seen, some short cuts were also taken. For example, most of the phoria values were not measured directly with prism, but were just estimated.

**Conclusion**

The correlations we might expect to find did not manifest in our data. This could be partly due to the limited tests that were performed. It could also be due to the fact that the

vast majority of our patients' findings were all within normal limits. Although screenings are an efficient way to see a large number of patients, the tests that are easiest to perform tend to be least predictive of academic performance.

In order to more accurately assess which children's visual systems are affecting their academic performance, future screenings should test visual skills that previous studies have found to specifically affect learning. The Developmental Eye Movement test (DEM) could be used to evaluate saccadic eye movement. Sequential processing has been shown to be highly correlated with saccadic eye movements and saccadic eye movements are correlated with academic performance.[2] Therefore, both processing and eye movement skills could be evaluated with the DEM. The DEM is also a relatively quick test that could be performed at a screening.[2] The VMI or the Wold Sentence Copy tests would also be useful tests to assess perceptual skills, as they have been found to be predictors of academic success.[9] Convergence insufficiency has also been shown to be significantly higher in the learning disabled population[5]. Although we did perform the NPC test, which is generally decreased in convergence insufficient patients, we only tested it once. Repeating it several times to observe the child's convergence system under fatigue might help us to obtain a true measure of the child's convergence system under near point strain.

By adding these tests to a screening of school children, a more accurate view can be obtained of the child's visual system under similar stresses they undergo in school. As a result, children whose poor visual skills affect their ability to learn can be identified before they fall too far behind in school.

## REFERENCES


1. Grisham JD, Simons HD. Refractive Error and the Reading Process: A literature Analysis. J Am Optom Assoc 1986; 57: 44-55.

2. Krumholtz, I. Results from a pediatric vision screening and its ability to predict academic performance. Optometry. 2000 July; 71(7):426-30.

3. Rosner J, Gruber J. Differences in the perceptual skills development of young myopes and hyperopes. Am J Optom Physiol Opt 1985; 62:501-4.

4. Rosner J, Rosner J. Some observations about visual perceptual skills development of young hyperopes and age of first correction. Clin Exp Optom 1986; 69:166-8.]

5. Simons HD, Grisham JD. Binocular Anomalies and Reading Problems. J Am Optom Assoc. 1987; 58: 578-87.

6. Griffin, Christenson, Wesson, and Erickson. Optometric Management of Reading Dysfunction. 1997. Butterworth-Heinemann, Newton. P. 98-99.

7. Kiely PM, Crewther SG, Crewther DP. Is there an association between functional vision and learning to read? Clin Exp Optom. 2001 Nov; 84(6):346-53.

8. Eden GF, Stein JF, Wood MH, Wood FB. Verbal and Visual problems in reading disability. J Learn Disability. 1995 May; 28(5)272-90.

9. Maples, WC. Visual factors that significantly impact academic performance. Optometry. 2003 January; 74(1):35-43.